FINAL REPORT TO THE USFS INTERMOUNTAIN STATION ON STREAM ECOLOGY RESEARCH PERFORMED DURING SUMMER 1992

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INTRODUCTION

The overall purpose of this study was to examine and compare macroinvertebrate assemblages from a number of streams in the Boulder Creek and Rapid River catchments. Streams of the Boulder Creek catchment have experienced various degrees of logging, whereas the adjacent Rapid River catchment is a designated natural area. Two streams of different size were sampled from each area, with an additional unlogged stream (Pony Creek) sampled from the Boulder Creek catchment. Besides the standard measures of interest, differences between streams were assessed using the refined rapid bioassessment protocols for small streams in Idaho (Robinson and Minshall 1992). One aspect of this technique relates the habitat quality or general stream condition with the overall condition or "health" of the macroinvertebrate assemblage. A second objective of the present study was to compare, using the rapid bioassessment procedure, the above study streams with selected streams of the Big Creek Catchment in central Idaho. Streams were selected to be of similar size, with two of these streams (Cliff and Cougar Creeks) having some part of their watershed burned by the 1988 Golden Fire, and the other two streams (Rush and Pioneer Creeks) draining unburned catchments.

METHODS

General methods used for the various segments of this study are summarized in Table 1. These are relatively routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Merritt and Cummins 1984, APHA 1990) or in more specific references listed in Table 1. Since annual maximum stream temperatures consistently occur during the July sampling season, annual temperature range can be estimated from observed stream temperatures based on a

Table 1. SUMMARY OF VARIABLES, SAMPLING METHODS, AND ANALYTICAL PROCEDURES FOR EVALUATING THE EFFECTS OF WILDFIRE ON STREAM ECOSYSTEMS

VARIABLE	SAMPLE TYPE	SAMPLING METHOD	ANALYTICAL METHOD	REFERENCE
A. Physical				
1. Temperature (°C)	P	Maximum-Minimum recording thermometers.	Direct Observation	
2. Discharge (m^3/s)	T	Velocity-depth profiles.	Calculation: Q=W• D• V; where W=width, D=mean depth, and V=velocity.	Bovee and Milhous 1978
Width (0.1m)	P	Nylon-reinforced meter tape.	Determine width of water and bankful width.	Buchanan and Somers 1969
Depth (0.1m)	T	Meter stick.	Determine water and bankful depths at sufficient intervals to give a good estimate of the mean. No more than 10% of flow should pass between measurements.	
Velocity (0.1m/s)	T	Small Ott C-1 current meter.	Determine velocities at 0.6 x depth (from the surface) at sufficient intervals to give a good estimate of the mean. No more than 10% of the flow should pass between measurements. Estimate bankful velocities from Manning's equation.	Gregory and Wailing 1973
3. Channel Gradient (%)	P	Inclinometer.	Measure water surface elevations over extended (150m) lengths upstream and downstream of the discharge transect.	
B. Chemical	P	"Grab" samples from center of stream.		
1. Alkalinity (mg/l)			Gran (in waters <40mg/l alkalinity) or methyl orange titration.	Talling 1973 APHA 1989
2. Hardness (mg/l)			EDTA titration.	APHA 1989
3. Specific Conductance (µmhos)		Determine in the field.	Temperature compensated portable YSI meter. Estimate total dissolved solids using standard conversion factor.	APHA 1989
C. Biological				
1. Periphyton	P/R	Collect samples from five separate cobblestones. Remove material from known area. Brush and rinse three times following prescribed technique. Collect material from each rock on a separate pre-combusted, tared, glass-fiber filter (Whatman GFF).	Acetone extraction of chlorophyll followed by spectrophotometric assay with correction for phaeopigments. Recombine acetone with sample and evaporate to dryness. Determine AFDM as described below.	Stockner and Armstrong 1971 Lorenzen 1966
2. Benthic invertebrates	P/R	Surber sampler fitted with 250 µm mesh net. Collect 5 samples per site in proportion to principal habitat types. Disturb substratum to depth of 10cm, remove all organic matter from larger inorganic particles, preserve in 5% formalin.	Separate invertebrates by species, count, dry at 60°C, and weigh. Determine population densities and biomass, species richness, dominance, diversity, and functional feeding group composition.	Platts et al. 1983 Merritt and Cummins 1984
3. Benthic organic matter	P/R	Recover from Surber samples described above.	Estimate percent composition of various plant components (including charcoal) dry at 60°C, ash at 550 °C, determine total AFDM.	

P = point sample
R = random throughout a defined lineal reach
T = transect across stream

minimum temperature of $0^{\circ}C$. Mean substratum size was determined by measuring 100 rocks randomly sampled throughout the channel along a 200 m reach of stream. In addition, we completed a rapid bioassessment of each stream for comparison of logged versus unlogged streams (Plafkin et al. 1989, Robinson and Minshall 1992).

Methods used for sampling macroinvertebrates are described in Platts et al. (1983). Procedures for summarizing data collected also are described in Table 1. Macroinvertebrates were examined in terms of density, biomass, species richness, and top ten most abundant taxa. The rapid bioassessment included a number of indices found important in describing differences among Idaho streams (Robinson and Minshall 1992). These indices of importance included: Shannon's Diversity (H'), Simpson's Index, % Filterers, % Dominant, Hilsenhoff Biotic Index (HBI)(Hilsenhoff 1988), Ephemeroptera/Plecoptera/Trichoptera (EPT) Richness, and the % EPT. These seven indices are scored, summed, and compared against the habitat assessment score for a stream, as described in Robinson and Minshall (1992).

Habitat assessment scores and biotic metrics also were calculated for selected streams of the Big Creek drainage in central Idaho: Rush Creek, Pioneer Creek, Cliff Creek, and Cougar Creek. These data were obtained as part of another study. Rush Creek is comparable size to Boulder Creek and WF Rapid River, while Pioneer, Cliff, and Cougar Creeks are of comparable size to Yellowjacket, Castle and Pony Creeks. Data for these four streams were collected during July 1991; except for Pioneer Creek which was collected in 1990.

Table 2. Summary table of chemical data for study streams.

Stream	Type	Stream Order	Temperature	Conductivity (u)	pH	Total Hardness (mg CaCO /liter)	Total Alkalinity (mg CaCO /liter)
Boulder Creek	Logged	4	18	72	8.3	18	44
West Fork Rapid River	Unlogged	4	12	90	8.0	20	39
Yellowjacket Creek	Logged	2	9	84	7.9	18	42
Castle Creek	Unlogged	2	15	183	8.1	30	72
Pony Creek	Unlogged	2	9	43	7.8	12	21

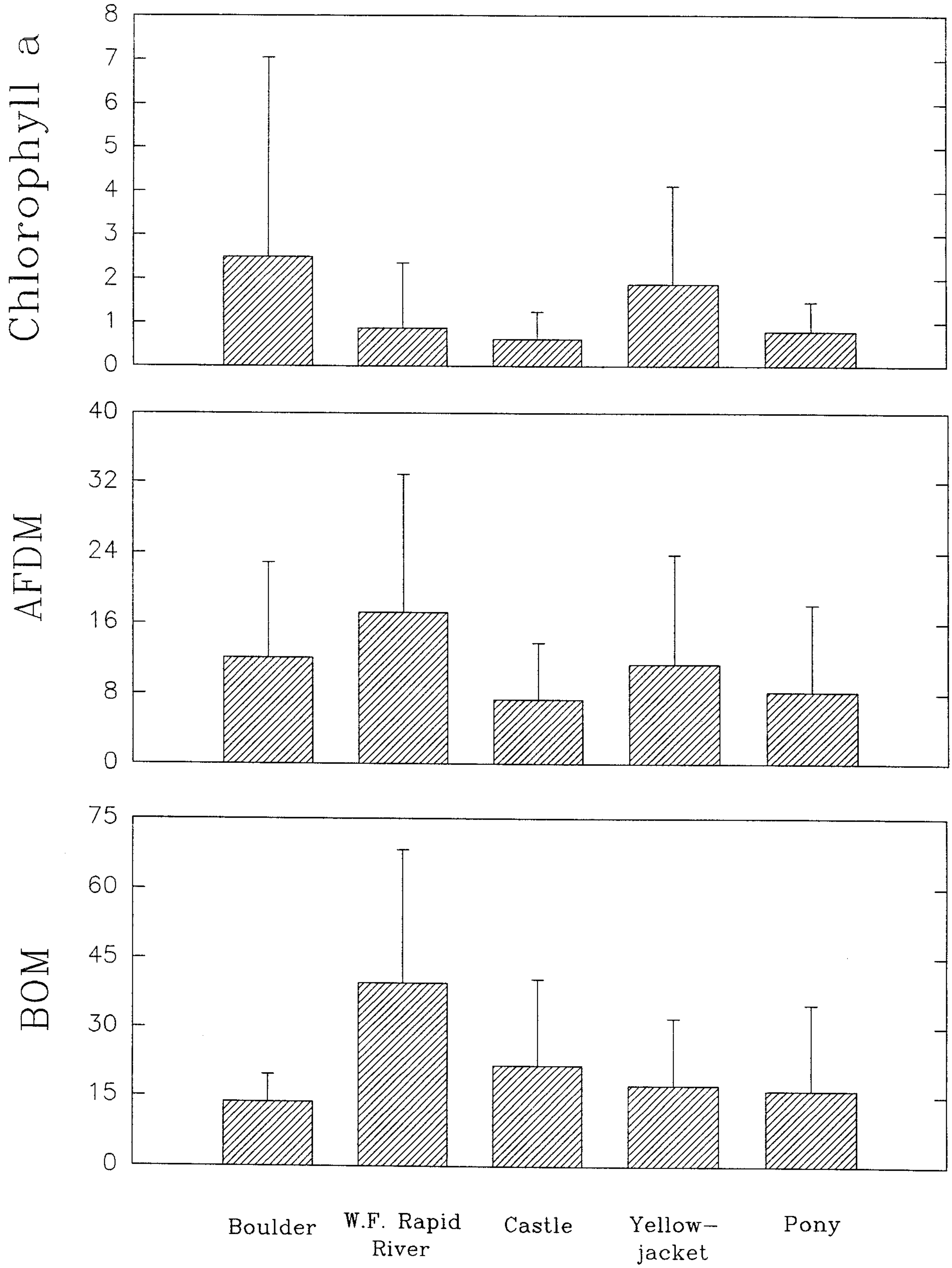

Figure 1. Mean chlorophyll a (ug/m^2), periphyton AFDM (mg/m^2), and benthic organic matter (g/m^2) for the study streams. Bars represent +1 standard deviation.

RESULTS

Chemical and Physical Measures

Few major chemical differences were found among the study streams (Table 2). Here, the exception was Castle Creek which displayed values twice as high as the other streams for specific conductivity, hardness, and alkalinity. Boulder Creek had higher maximum temperatures than the similar-sized WF Rapid River, and Castle Creek had higher water temperatures than Yellowjacket Creek (Table 2). Although not statistically significant, the logged streams exhibited greater mean chlorophyll a values than unlogged streams, being about 2X as high (Fig. 1). In contrast, algal AFDM displayed opposite trends in the 4th order streams with biomass being greater in WF Rapid River than in Boulder Creek. WF Rapid River also had the greatest amount of benthic organic matter (BOM) than the other streams, being 3X higher than BOM levels in Boulder Creek (Fig. 1). The 2nd order streams all displayed similar levels of BOM.

The primary physical difference between paired streams was in width:depth ratio where logged streams displayed greater ratios than similar size unlogged streams (Table 3). Further, maximum depth was greater in logged than in unlogged reference streams suggesting some channel cutting has occurred. Pony Creek appeared to be physically different than other similar size streams. For example, maximum depth and mean substrate size was greater in Pony Creek than in Yellowjacket or Castle Creeks, but the width:depth ratio was similar to the unlogged Castle Creek (Table 3). These results become evident in cross-section profiles for the study streams, with the logged streams showing greater widths and depths than respective reference streams (Fig 2.). The exception, again, is Pony Creek which displayed greater mean water depths and channel widths than similar size streams. Pony Creek also had greater coefficients of variation for these parameters suggesting a high degree of habitat heterogeneity.

Table 3. Summary table of physical data for study streams.

Stream	Type	Slope (%)	Discharge (m3/s)	Velocity (m/s)			Baseflow Depth (cm)			Maximum Depth (cm)			Width:Depth Ratio		Substrate size (cm)			Embededness (%)		
				Mean	Std.	CV	Mean	Std.	CV	Mean	Std.	CV	Mean	Std.	Mean	Std.	CV	Mean	Std.	CV
Boulder Creek	Logged	2.0	0.4	0.1	0.1	0.8	18.5	9.4	0.5	55.4	19.8	0.4	80	33	16.9	16.9	1.0	27.3	32.2	1.2
West Fork Rapid River	Unlogged	2.5	1.8	0.2	0.1	0.5	24.7	11.7	0.5	31.3	14.4	0.5	41	9	13.4	10.3	0.8	27.8	55.4	2.0
Yellowjacket Creek	Logged	8.0	0.0	0.1	0.1	0.7	9.8	5.0	0.5	35.9	12.7	0.4	35	24	7.9	9.5	1.2	46.4	40.2	0.9
Castle Creek	Unlogged	11.5	0.0	0.1	0.1	0.7	9.3	5.1	0.5	19.0	7.9	0.4	26	6	10.0	11.7	1.2	36.7	38.4	1.1
Pony Creek	Unlogged	13.0	0.1	0.1	0.1	0.9	12.8	8.6	0.7	52.5	25.9	0.5	25	6	31.2	36.2	1.2	45.3	35.0	0.8

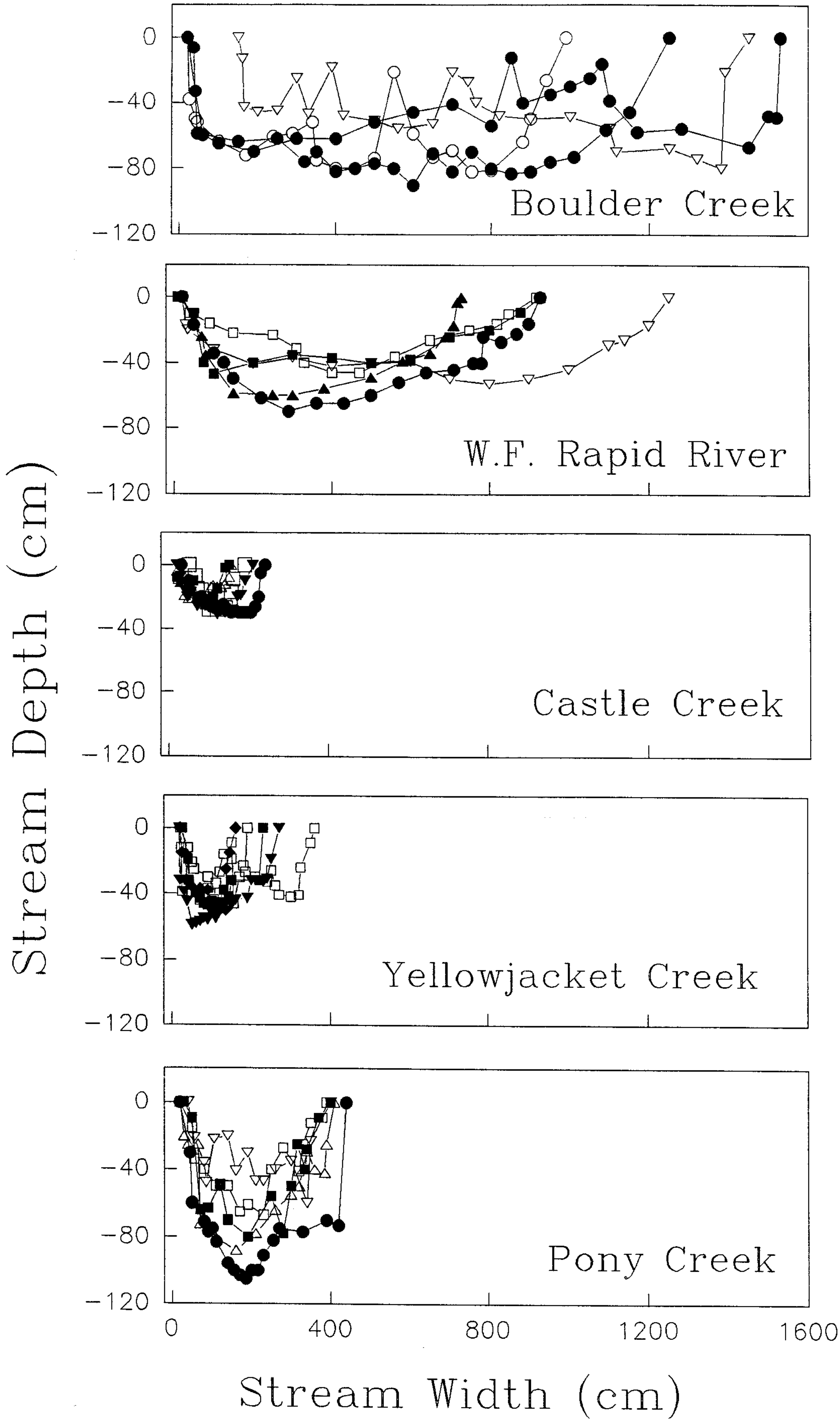

Figure 2. Cross-sectional transects of study streams.

Macroinvertebrate Assemblages

The abundance of macroinvertebrates was greater in the larger 4th order streams than in the 2nd order streams, except for Castle Creek (Fig. 3). Macroinvertebrate biomass also was greater in these larger streams, with similar biomass values found among 2nd order streams. Species richness, on the other hand, was substantially greater in Castle Creek, by an additional 10 taxa, than in any of the other study streams.

Chironomidae and Oligochaeta were the predominant taxa observed at most sites, except Castle Creek where *Heterlimnius* and *Baetis bicaudatus* were predominant (Table 4). Boulder Creek and WF Rapid River were quite similar with eight of the ten most abundant taxa being the same. *B. bicaudatus* was abundant in Yellowjacket and Pony Creeks, but did not occur in the ten most abundant taxa in Castle Creek. Castle Creek and Yellowjacket Creek shared six of the ten most abundant taxa. Turbellarians were abundant in Yellowjacket Creek, while *Drunella doddsi* was abundant in Castle (Table 4). *Serratella tibialis* and *Yoroperla brevis* were common taxa in Pony Creek.

Rapid Bioassessment Metrics

Habitat scores were quite similar among study streams and reflected good habitat quality, ranging from 121 for Castle Creek to a high of 153 for Pony Creek (Table 5). No differences were observed between logged and unlogged study streams. The greatest dissimilarities were observed in the % cover, water temperature, substratum size, and flow heterogeneity categories. Here, Pony Creek scored highest for % cover, water temperature (with Yellowjacket Creek), and substratum size, but lowest for the flow heterogeneity category (Table 5).

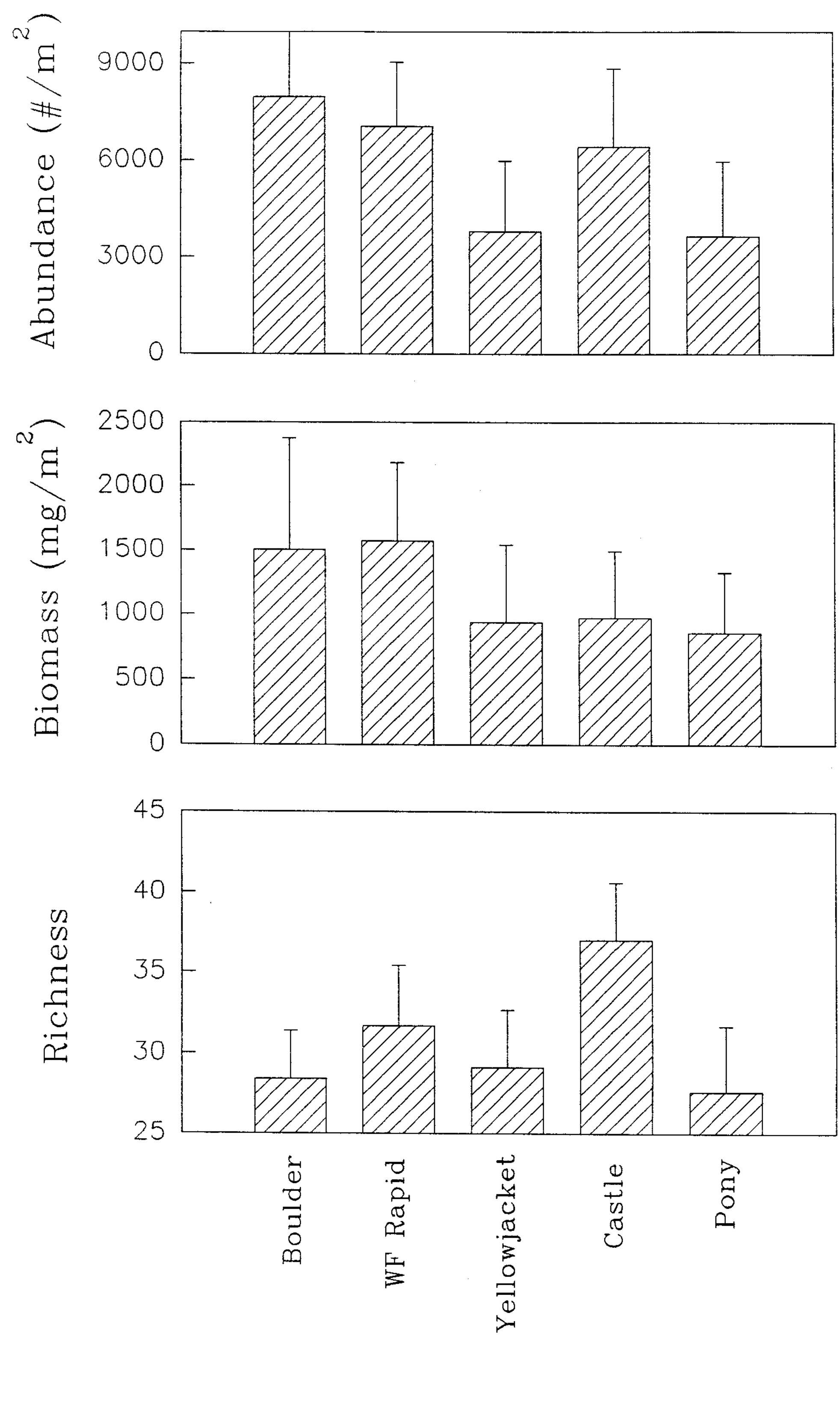

Figure 3. Abundance ($\#/m^2$), biomass (mg/m^2), and richness for macroinvertebrate samples from the study streams.

Table 4. Top ten taxa based on abundances (number per square meter)

Boulder Creek	Mean	SD	Relative
Chironomidae	1817	1173	0.228
Oligochaeta	1453	706	0.183
Baetis bicaudatus	635	448	0.080
Serratella tibialis	610	1278	0.077
Heterlimnius sp.	524	329	0.066
Cinygmula sp.	416	226	0.052
Drunella doddsi	399	277	0.050
Nematoda	284	437	0.036
Ostracoda	194	452	0.024
Simulium sp.	188	211	0.024
WF Rapid Creek			
Oligochaeta	2151	1634	0.305
Chironomidae	1013	502	0.144
Baetis bicaudatus	813	501	0.115
Heterlimnius sp.	383	256	0.054
Cinygmula sp.	359	114	0.051
Paraleptophlebia sp.	308	122	0.044
Nematoda	248	330	0.035
Ostracoda	243	342	0.035
Serratella tibialis	181	81	0.026
Suwallia sp.	166	99	0.024
Yellowjacket Creek			
Oligochaeta	1071	876	0.282
Chironomidae	449	285	0.118
Turbellaria sp.	371	216	0.098
Cinygmula sp.	317	224	0.084
Epeorus Sp.	219	303	0.058
Ephemerella infrequens	162	185	0.043
Nematoda	128	165	0.034
Micrasema sp.	118	159	0.031
Rhyacophila vagrita	99	67	0.026
Zapada columbiana	86	108	0.023
Castle Creek			
Baetis bicaudatus	1230	1100	0.192
Heterlimnius sp.	1105	432	0.172
Drunella doddsi	793	585	0.124
Micrasema sp.	701	350	0.109
Chironomidae	427	260	0.067
Oligochaeta	272	181	0.042
Zapada columbiana	227	158	0.035
Rhyacophila vagrita	163	99	0.025
Cinygmula sp.	126	80	0.020
Megarcys	124	79	0.019
Pony Creek			
Oligochaeta	1151	1327	0.316
Chironomidae	712	558	0.195
Serratella tibialis	320	371	0.088
Cinygmula sp.	148	142	0.041
Turbellaria sp.	138	169	0.038
Baetis bicaudatus	129	120	0.035
Yoroperla brevis	124	101	0.034
Rhyacophila vagrita	109	79	0.030
Epeorus Sp.	97	69	0.027
Nematoda	78	143	0.021

Table 5. Relative scores for habitat metrics used for habitat assessment among study streams.

STREAM	WIDTH/ DEPTH RATIO	% COVER	CHL-a	TEMP (C)	SPEC. COND.	SUBST AVG	EMBED AVG	SLOPE	FLOW	CAN COVER	POOL RIF	BANK STAB	STREAM COVER	RIP WIDTH	TOTAL SCORE
Boulder Ck.	0	5	4	1	14	13	9	9	18	17	8	10	10	9	127
WF Rapid Ck.	1	3	10	11	14	12	9	8	16	12	8	10	4	10	128
Yellowjacket Ck.	1	5	7	15	14	4	6	15	13	19	10	10	10	10	139
Castle Ck.	3	0	12	4	9	7	8	15	12	14	12	10	10	5	121
Pony Ck.	3	15	10	15	15	15	6	15	8	19	7	10	7	8	153

Categories and scores follow Robinson and Minshall (1992).

Similarily, the macroinvertebrate biotic score reflected similar conditions among the study streams, ranging from 29 in the 4th order streams and Pony Creek to 35 in Castle Creek (Table 6, Fig. 6). Recall that Castle Creek also exhibited the highest species richness among study streams. Here, the greatest difference among streams was for the Hilsenhoff Biotic Index (Fig. 4), where the 4th order sites scored low relative to the smaller 2nd order streams. The 4th order streams also displayed lower in the % EPT category (Table 6), however all sites were indicative of a "healthy" biota. Indeed, Castle Creek had high scores for all biotic categories (Figs. 4,5).

Comparison of Metrics with Big Creek Streams

Rush Creek exhibited similar habitat conditions as Boulder Creek and WF Rapid River as reflected in comparable habitat assessment scores (Fig. 7). In contrast, the biotic metric score was somewhat lower in Rush Creek than in Boulder Creek and WF Rapid River, but still reflected a relatively "healthy" macroinvertebrate assemblage (Fig. 7). The lower score in Rush Creek resulted from a predominance of filterers (Table 7); namely the filter-feeding caddisfly *Brachycentrus*.

Pioneer, Cliff, and Cougar Creeks displayed higher habitat scores than Yellowjacket, Castle and Pony Creeks (Fig. 7). These higher scores reflected substantially higher metric scores for width:depth ratio, % cover, and chlorophyll a; however all streams analyzed exhibited good habitat conditions as indicated from the habitat assessment score. As with Rush Creek, Pioneer, Cliff, and Cougar displayed lower biotic metric scores than Yellowjacket, Castle, and Pony Creeks, again resulting from the predominance of filterers in these Big Creek streams (Table 7).

Table 6. Absolute values and scores for metrics used for refined biotic index.

STREAM	EPT RICHNESS	SCORE	HBI INDEX	SCORE	%DOM	SCORE	H' DIVERSITY	SCORE	SIMPSON'S INDEX	SCORE	% FILTERERS	SCORE	% EPT	SCORE	MODIFIED SCORE MAX=35
Boulder Ck.	16.3	5	4.09	1	0.283	5	3.38	5	0.148	5	0.041	5	0.570	3	29
WF Rapid Ck.	19.3	5	4.37	1	0.309	5	3.45	5	0.166	5	0.047	5	0.608	3	29
Yellowjacket Ck.	18.4	5	3.62	3	0.302	5	3.51	5	0.162	5	0.019	5	0.628	5	33
Castle Ck.	23.0	5	2.96	5	0.228	5	3.75	5	0.118	5	0.032	5	0.618	5	35
Pony Ck.	17.2	5	3.80	3	0.323	3	3.35	5	0.201	3	0.024	5	0.619	5	29
*SCORE															
5	>14.6		<3.59		<0.32		>2.45		<0.18		<0.06		>0.61		
3	12.7-14.6		3.59-3.90		0.32-0.38		2.26-2.45		0.18-0.22		0.06-0.08		0.53-0.61		
1	<12.6		>3.90		>0.38		<2.26		>0.22		>0.08		<0.53		

* Scores follow Robinson and Minshall (1992).

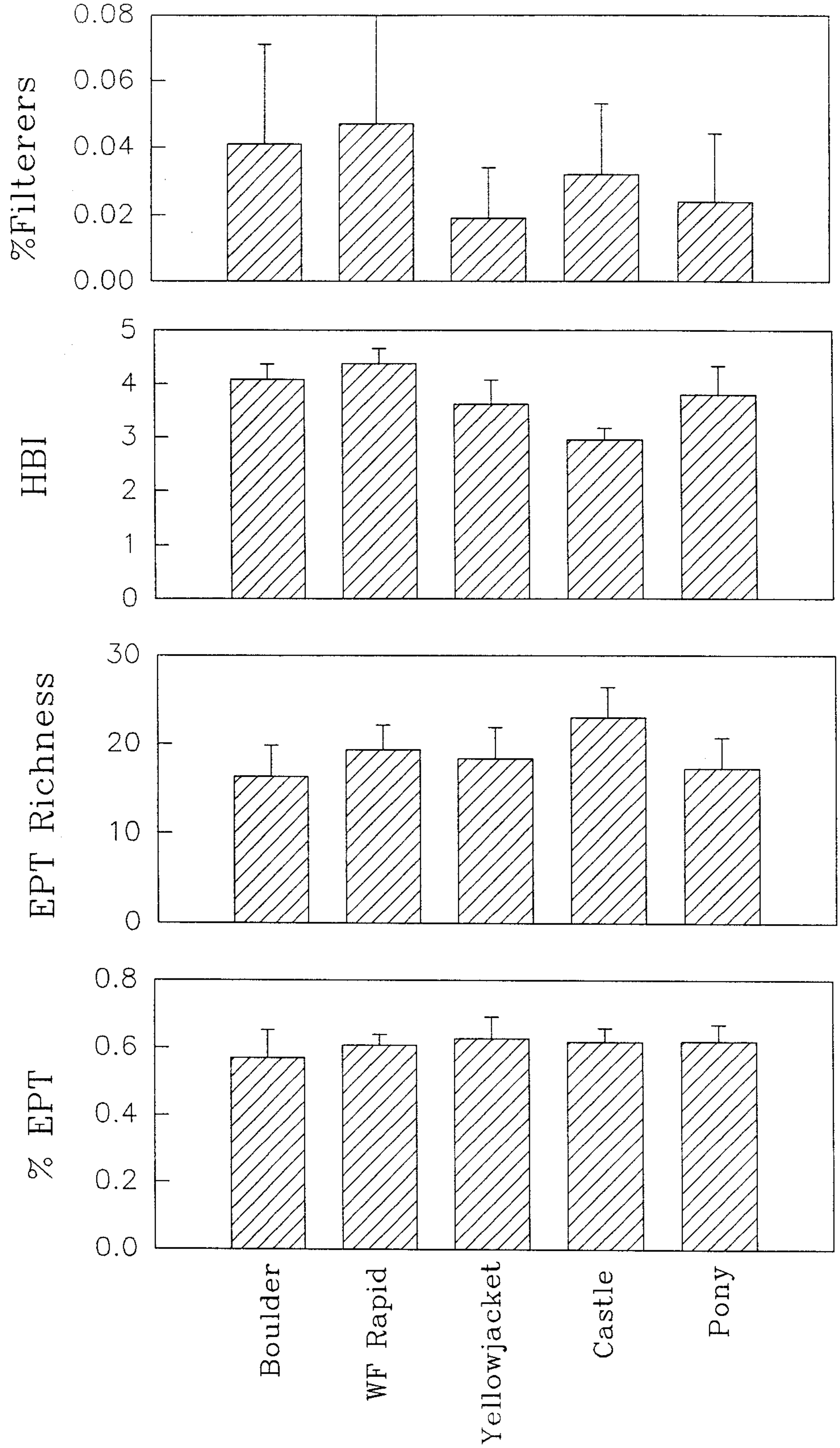

Figure 4. Percent filterers, Hilsenhoff Biotic Index (HBI), number of Ephemeroptera+Plecoptera+Trichoptera taxa (EPT richness), and percent EPT for study streams.

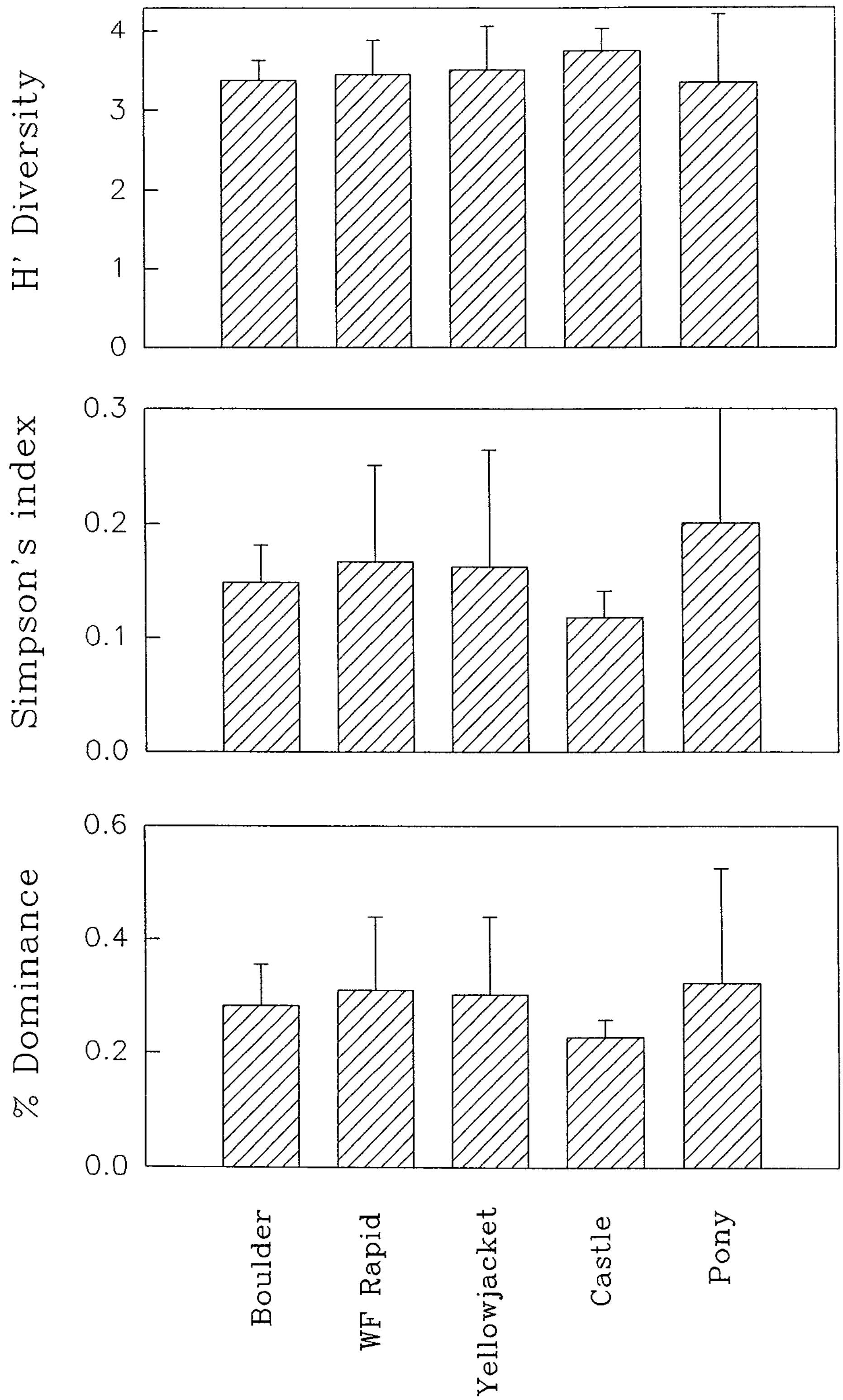

Figure 5. H' Diversity, Simpson's index, and % Dominance of macroinvertebrate samples from the study streams.

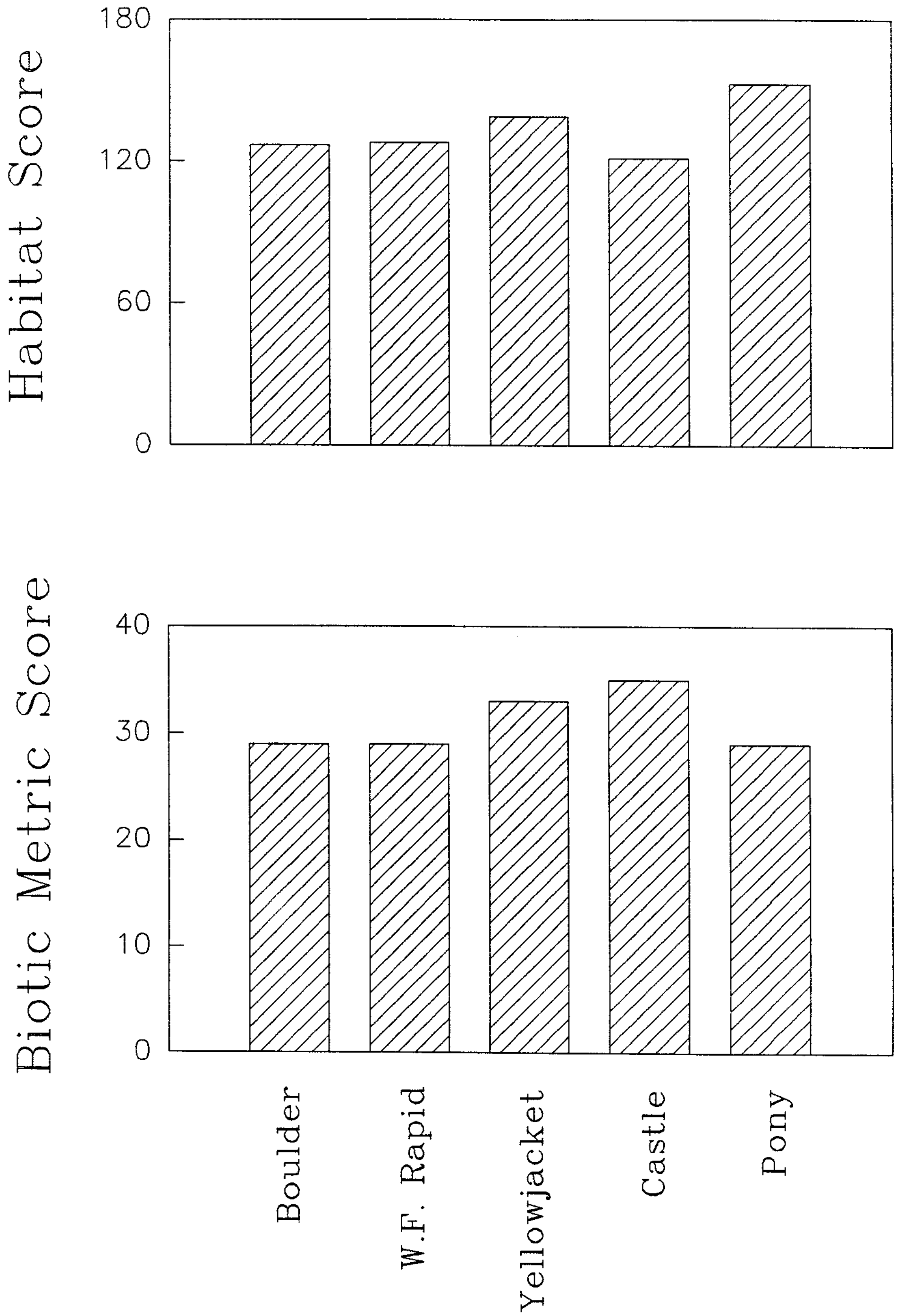

Figure 6. Habitat assessment and biotic metric scores for the study streams.

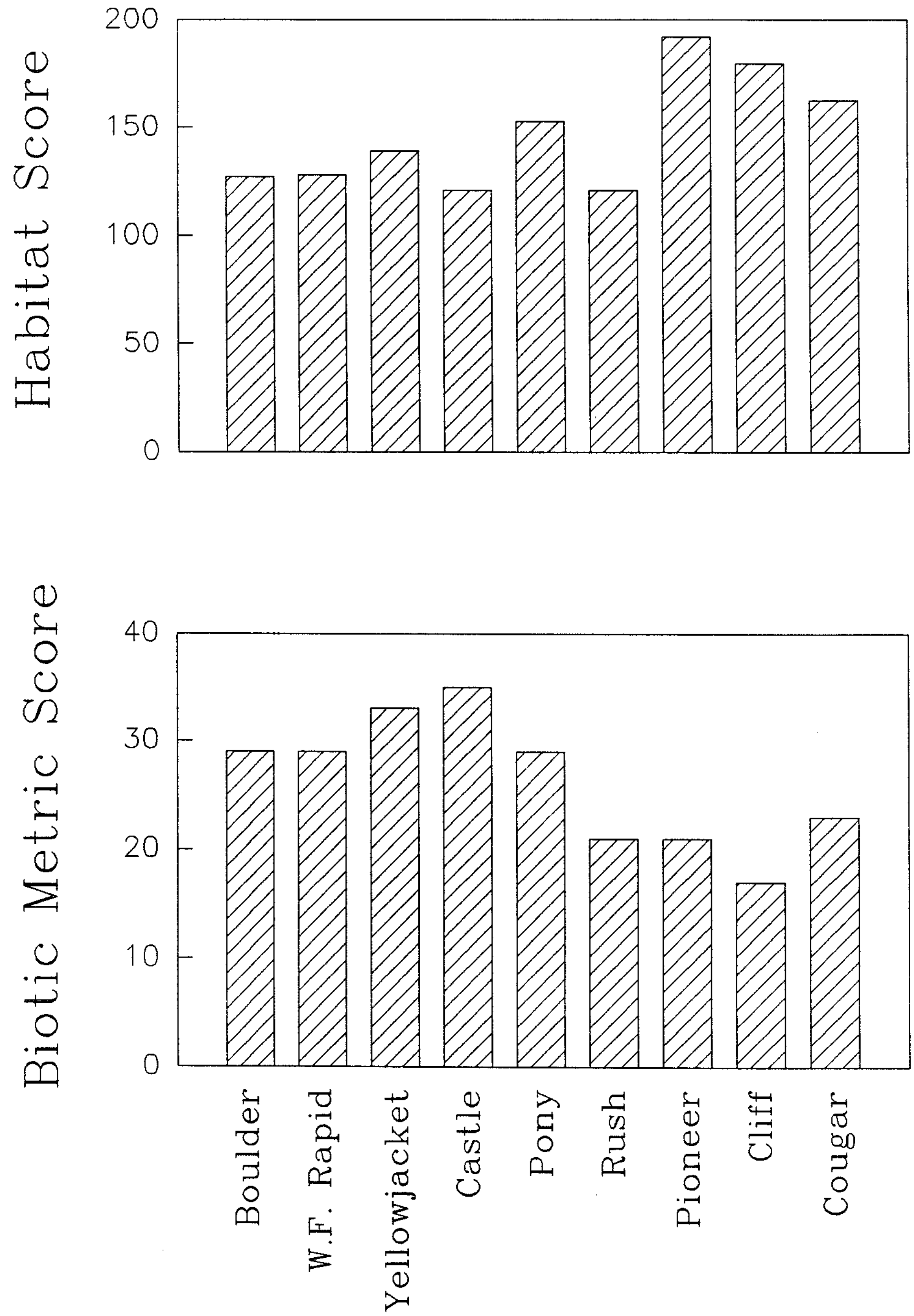

Figure 7. Comparison of habitat scores and biotic metric scores of study streams and selected streams of the Big Creek Drainage.

Table 7. Habitat assessment and biotic metric scores for selectedstreams of the Big Creek drainage.

HABITAT ASSESSMENT CATEGORIES AND RESPECTIVE SCORES

STREAM	W:D RATIO	% COVER	CHL. a	TEMPERATURE	SPECIFIC CONDUCTANCE	SUBSTRATA	EMBED	SLOPE	FLOW	COVER	POOL/RIFF	BANK STABILITY	STREAM COVER	RIPARIAN WIDTH	TOTAL
RUSH	13	5	5	1	13	11	15	6	8	10	8	9	10	10	121
PIONEER	15	15	15	15	14	13	13	15	17	20	10	10	10	10	192
CLIFF	15	15	15	8	13	15	6	14	17	20	12	10	10	10	180
COUGAR	15	15	15	6	12	8	8	15	15	18	11	8	9	8	163

BIOTIC METRIC CATEGORIES AND RESPECTIVE SCORES

STREAM	EPT RICHNESS	HBI	% DOMINANCE	H′	SIMPSONS INDEX	% FILTERERS	% EPT	TOTAL
RUSH	3	5	1	5	1	1	5	21
PIONEER	3	5	5	3	1	1	3	21
CLIFF	1	5	1	5	1	1	3	17
COUGAR	1	5	5	5	3	1	3	23

*After Robinson and Minshall 1992.

DISCUSSION

We found little influence of logging on the study streams in the Boulder Creek catchment probably reflecting the relatively wet climate, moderate topography, and silviculture practices of this region. Timber removal in the Boulder Creek catchment seems to be more selective (small areas being disturbed at any one time) and better dispersed in time and space than they seem in other parts of the state. We observed rather rapid recovery of riparian vegetation, suggesting that the effects of logging operations are quickly mitigated in affected stream systems. However, some physical measures indicated possible effects by logging, namely the increase in width:depth ratios for logged streams relative to unlogged streams of the Rapid River catchment. Further, the higher values for chlorophyll a suggest subtle changes in environmental conditions through increases in light, water temperatures, or nutrient levels. Riparian cover appeared similar at all study streams suggesting similar solar conditions. Boulder Creek did have higher water temperatures than WF Rapid River, whereas the smaller Yellowjacket Creek had lower temperatures than respective Castle Creek. Nutrients levels may have been greater in the logged catchment, but were unmeasured in this study.

Macroinvertebrate assemblages were quite similar among streams and catchments, being indicative of "healthy" stream systems. Castle Creek displayed much higher densities, species richness and diversity than the other study streams. Further, the greater species richness was attributed to greater number of EPT species. Castle Creek was chemically different than the other streams having specific conductivities, hardness, and alkalinity values ca. 2X greater than in the other streams. Water temperatures also were markedly warmer in Castle (15°C) than in Yellowjacket or Pony Creeks (9°C). A more intensive investigation would be required to determine the cause of the enhanced biotic condition of Castle Creek.

There appears to be some different environmental conditions present in the Big Creek catchment than in the Boulder Creek and Rapid River catchments, although all streams scored relatively high in respect to the habitat assessment score. The Big Creek catchment is climatically drier, and soils appear to be more erodable than in these other two catchments. Filter feeders were predominant in the macroinvertebrate assemblages of Big Creek streams as reflected in the lower biotic metric scores, although these scores also were relatively high.

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